Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal Form

Section 1. General administrative information

Evaluate estuarine and nearshore-ocean migratory behavior of juvenile salmonids

Bonneville project number, if an ongoing project 9035

Business name of agency, institution or organization requesting funding

National Marine Fisheries Service

Business acronym (if appropriate) NMFS/NWFSC

Proposal contact person or principal investigator:

Name	Richard D. Ledgerwood
Mailing Address	Point Adams Biological Station P.O. Box 155
City	Hammond
ST	OR
Zip	97121-0155
Phone	503-861-1853
Fax	503-861-2589
Email address	dick.ledgerwood@noaa.gov

Subcontractors.

Organization	Mailing Address	City, ST Zip	Contact Name
NA			

NPPC Program Measure Number(s) which this project addresses.

Measures 4.2, 5.7, 5.8, and 7.2

NMFS Biological Opinion Number(s) which this project addresses.

RPAs 13, 14 of NMFS Biological Opinion (Section 7 of ESA), Operation of the FCRPS.

Other planning document references.

NA

Subbasin.

Columbia River estuary and nearshore ocean

Short description.

Compare migration patterns during February-April of juvenile chinook reared in the Terminal Fishery Project and tracked individually through the Columbia River estuary to the ocean using sonic tags. Fish will be released at two sites (RKms 20 and 5) and tidal current will be used to attempt forced early ocean entry while monitoring changing environmental and physiological variables.

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
+	Anadromous fish		Construction		Watershed
	Resident fish	+	O & M		Biodiversity/genetics
	Wildlife	+	Production		Population dynamics
X	Oceans/estuaries	X	Research	+	Ecosystems
	Climate	+	Monitoring/eval.	X	Flow/survival
	Other	+	Resource mgmt		Fish disease
		+	Planning/admin.	+	Supplementation
			Enforcement		Wildlife habitat
			Acquisitions	+	enhancement/restoration

Other keywords.

Sonic fish-tracking, predation, saltwater challenge, migration, transportation

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship
93-06000	"Columbia River Terminal Fishery Research"/ Net-pen rearing study to establish a sport and commercial terminal fishery in Youngs Bay	Source of study fish for tracking.
92-02200	"Physiological assessment and behavioral interactions of wild and	Source of study fish for tracking.

	hatchery juvenile salmonids"/Study to test the effects of winter dormancy and accelerated spring growth on smolt-to-adult survival of spring chinook salmon in the Columbia River terminal fishery (project 93-06000)	

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Track individual fish using sonic fish-tags following release in Youngs Bay, in the Columbia River estuary, and in the nearshore ocean during February, March, and April.	a	Surgically or gastrically implant sonic tags in 5 to 10 juvenile spring chinook salmon each month in February, March, and April 1999.
		b	Individually track the tagged fish following release as they migrate in Youngs Bay, the Columbia River estuary, and nearshore ocean.
2	Record environmental parameters and physiological parameters possibly associated with behavioral differences during migration.	a	Physiological parameters (degree of smoltification, condition factor, and others) recorded as part of the normal CEDC rearing processes (project 93-06000) or for other ongoing research at the facility (project 92-02200).
		b	Environmental parameters through the water column (temperature, salinity, dissolved oxygen) recorded during the tracking process using a multiparameter submersible probe (Hydrolab).
		c	Correlate temporal differences in fish migration behavior with environmental or physiological

			differences.

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	01/1999	05/1999	80
2	02/1999	07/1999	20

Schedule constraints.

Study fish not made available by CEDC.

Describe major milestones if necessary.

Fish are normally transferred to CEDC at subyearling-age from Oregon Department of Fish and Wildlife facilities (Willamette River hatchery) in November and reared through the winter to yearling-age for release in the spring. If fish were unavailable for net-pen rearing, they would be unavailable for this study. In addition, the proposed February tagging is contingent upon representative fish attaining sufficient size (>125-mm fork-length) for tagging.

Completion date.

2002

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel	Total base pay excluding contract labor (see below).	$67.6 K
Fringe benefits	Leave surcharge and Employee contribution	29.3
Supplies, materials, non-expendable property	Vessel costs, sonic tags (40)	19.5
Operations & maintenance		0.0
Capital acquisitions or improvements (e.g., land, buildings, major equip.)	NMFS has on hand two 300 kHz tracking receivers matching the LoTek brand sonic tags used in 1997.	0.0

PIT tags.	# of tags:	0.0
Travel		1.7
Indirect costs	SLUC and NOAA overhead charges.	41.8
Subcontracts		0.0
Other		0.0
TOTAL:	Based on 1997 pay-rates and other costs.	$159.9 K

Outyear costs

Note. We are providing a placeholder for outyears that is dependant in part on the FY'99 research results. If we conclude that forced early ocean entrance is feasible, then a follow-up research effort using marked groups represented by coded wired tags (CWT) is necessary to evaluate survival (contribution) and straying of returning adults. Sonic tracking would be a small part of the CWT effort to further our understanding of migration behavior in those years.

Outyear costs	**FY2000**	**FY01**	**FY02**	**FY03**
Total budget	$ 320.0 K	$320.0 K	$350.0 K	$350.0 K
O&M as % of total				

Section 6. Abstract

Knowledge of the migrational behavior and survival of juvenile salmonids as they move from fresh water into brackish water and saltwater environments is limited. Results obtained during a feasibility study in April 1997 indicated that the primary influence on migrational behavior of tagged fish in the estuary was tidal current and that study fish did not avoid entering salt water when released within one ebb-tide cycle of ocean entrance.

Research proposed for 1999 would further evaluate juvenile salmonid migrational behavior as related to release timing (degree of smoltification) to determine whether these fish will volitionally enter the ocean environment or whether it is possible to force juvenile fish into the ocean environment earlier in the year and thereby better avoid avian and other predation while reducing culture costs. In addition, we will assess the feasibility of a net-pen transport study utilizing CWT-tagged fish to examine contribution benefits and possible straying of returning adults. We propose to accomplish these objectives by releasing sonic-tagged juvenile spring chinook salmon in Youngs Bay (Columbia River estuary) from February to April and tracking them through the estuary to the nearshore ocean; we will also transport test groups to within one ebb-tide cycle of the ocean entrance and track them into the nearshore ocean.

With direct relevance to predation, transportation, and hatchery production issues, the proposed research pertains to measures 4.2, 5.7, 5.8, and 7.2 of the Columbia River Basin Fish and Wildlife Program.

Section 7. Project description

a. Technical and/or scientific background.

The contribution of the estuary and ocean to variations in survival of juvenile salmonids remains poorly known (Boehlert 1997). Currently, there is much concern that avian and other predation of migratory fish in the estuary has a large impact on survival of juvenile salmonids (Schreck et al., In Prep.; Jim Hill, Clatsop Economic Development Commission (CEDC), pers. commun., 6 Oct 1997). Fish groups that spend considerable time in the estuary, perhaps for physiological adjustment prior to entrance into salt water (Wagner et al. 1969) or added growth to some threshold minimum size (Reimers 1973), would be subjected to higher predation and exhibit lower survival than fish groups that egress into the ocean rapidly. On the other hand, small fish swept into the ocean by strong tidal currents when physiologically ill-prepared to adapt to the sudden osmotic challenge could also exhibit poor survival.
Migration behavior of juvenile salmonids passing through the Columbia River estuary and into the nearshore ocean is poorly documented. Beginning in 1966, NMFS researchers attempted to evaluate migrational characteristics and relative survival differences of marked groups of juvenile salmonids released throughout the Columbia River Basin. Sampling was conducted in the estuary and occasionally in the nearshore ocean (Miller et al. 1983, Dawley et al. 1986, Ledgerwood et al. 1994, Miller 1992). Purse and beach seines were utilized to recover marked individuals and marked fish recovery information was used to infer migrational behavior for an entire release or treatment group to and through the estuary (Dawley et al. 1986).

Recent miniaturization in sonic fish-tagging technology has made it possible to track individual juvenile salmonids from fresh water into brackish and saltwater environments where knowledge of migrational behavior and survival is lacking. Results obtained during a feasibility study in April 1997 indicated that the primary influence on migrational behavior of tagged fish in the estuary was tidal current and there was little indication that study fish could avoid entering salt water (Ledgerwood et al., In prep.).

The research proposed herein would continue to evaluate juvenile salmonid migrational behavior as related to release timing (degree of smoltification) with a goal of determining whether it is possible to force juvenile fish into the ocean environment at an earlier than normal date to avoid avian predation and to reduce fish-culture costs. We propose to implant sonic fish-tags and track individual fish daily for 10 days each in February, March, and April. In addition, we will track 10 fish during this period released directly into the ocean to examine migrational behavior of fish suddenly challenged by a saltwater environment.

In the April 1997 study, movement of tagged fish released near the net-pen site seemed dictated by the prevailing tidal current; i.e., fish released near high tide moved downstream with the ebb current and fish released near low tide moved upstream on the flood current (Ledgerwood et al., In prep.). Tracking efforts extending across multiple tide changes supported the conclusion that movement of tagged fish was primarily related to tidal current. In general, fish remained stationary only during time periods of low current slack tides and this behavior seemed unaffected by daylight/darkness. In general, it required about one high to low tide cycle (4 to 6 hours) for fish to traverse the 9-km distance from the net-pen site to the confluence of Columbia River/Youngs Bay (about 1.5 to 2.5 km/h, assuming straight line river channel travel). Fish that did not make it into the Columbia River and two fish that entered the mainstem Columbia River just at low tide moved back upstream into Youngs Bay after the tide changed to flood current. One fish which was tracked for over 16 hours moved initially downstream on the ebb current from the net-pen release site River Kilometer (RKm) 29 to the confluence with the Columbia River (RKm 20), then upstream with the flood current into the Lewis and Clark River (to RKm 25), and finally back downstream on the following ebb tide where it reentered the Columbia River and was lost near Tansy Point (RKm 16).

The 1999 study design would provide that fish be released for tracking near high tide on an alternating basis at the two sites: the confluence of Youngs Bay with the Columbia River, RKm 20 (control group), and a location just upstream from the Columbia River bar (about RKm 5) (treatment group). Based on 1997 results, fish released at the control location would be carried downstream on the ebb current to the river's mouth in about 6 hours, whereas treatment fish would reach the river's mouth near the peak of the ebb current and presumably be swept farther out to sea. Though we have no method to determine depth of tracked fish, we intend to measure various physical parameters through the water column (salinity, temperature, dissolved oxygen, conductivity, and pH) during tracking and to correlate these parameters with migration behavior if possible.

If fish released during any of the three study periods do not travel quickly downstream with the ebb current, but rather seek sanctuary in the shallows, their behavior would indicate possibly higher susceptibility to predation and help explain higher adult contribution rates for juveniles released at a larger size and degree of smoltification in April (Hirose et al., In prep.).

We would release fish at the two study locations on tides of similar magnitude for each monthly series of releases and compare possible differences in the speed of downstream movement. A goal of the study is to observe migrational behavior in the Columbia River estuary and ocean during the different time series when fish size and physiological condition (degree of smoltification) are changing.

b. Proposal objectives.

1) Track individually sonic-tagged fish in the Columbia River estuary and in the nearshore ocean during February, March, and April. Hypothesis--there are no temporal differences in migrational behavior of juvenile spring chinook salmon during the study

period. The hypothesis would be evaluated by comparison of detailed fish tracks recorded with Global Position Satellite (GPS), plotted as overlays on nautical charts, such that speed and location of movements can be compared for individual fish.

2) Record environmental parameters and physiological parameters possibly associated with behavioral differences during migration.

a. A database of environmental parameters recorded through the water column (temperature, salinity, dissolved oxygen) would be created and referenced to GPS position, date, and time of fish movements. These measurements will enable us to better standardize comparisons of fish tracks recorded temporally under different tidal and river conditions.

b. Physiological assessments during the rearing period of these fish are obtained as part of BPA project 92-02200. Fish used for tracking will be selected from those study pens, therefore those data will generally describe the changing physiological state of our study fish at the time of tagging.

3) Products of the research.

a. Tracking data including: GPS location information, date and time, sonic tag number and associated data, physical data from the marked fish (length and treatment information), and environmental data (hydrolab recordings during tracking) will be stored in a relational database (Microsoft Access).

b. Physiological data and other rearing information will be obtained from the Terminal Fishery personnel and other researchers for inclusion in the analyses of the tracking data.

c. Tracking information will be extracted from the database and plotted as a series of overlay files on NOAA navigational or other charts.

d. Results of the analyses and the plotting data will be presented in an annual report and, if warranted, the final data will be published in a peer reviewed journal.

c. Rationale and significance to Regional Programs.

The migrational behavior of sonic-tagged fish tracked in April 1997 may have been influenced by their advanced stage of smoltification (Walton Dickhoff, pers. commun., Sept. 1997). Time-of-release studies conducted using CWT-tagged fish at the CEDC facilities in earlier years indicated greater adult contribution from fish released during April (compared to February or March releases) but those results may have been influenced by several factors including degree of smoltification, fish size, and avian predation. Smaller sized and presumably less smolted fish may not rapidly egress to the ocean, and if smaller fish remain for extended periods within the shallow confines of Youngs Bay, they could be subjected to increased predation (Caspian terns and cormorants) as reported by facilities personnel. Rearing fish longer, even though sustaining higher feed costs, increased returns, perhaps due to more rapid emigration. If sonic tracking results indicate that fish reared in Youngs Bay net-pens may be transported closer to the ocean and successfully "flushed" into the marine environment by tidal current, a follow-up study utilizing CWTs to evaluate possible survival benefits and straying concerns with returning adult fish could be conducted by moving (towing or floating) test net-pens closer to or into the ocean to release fish. If juvenile chinook salmon reared in Youngs Bay net-pens can be forced into the ocean by tidal currents, avian and other predation prevalent in the estuary may be reduced. Extended residency and predation on early release groups may have influenced earlier time-of-release studies conducted at the net-pen site. Earlier release of these cultured fish has the potential to reduce costs (feed and maintenance) of the terminal fishery program and improve production.

In addition, the Youngs Bay net-pen rearing facilities may provide a best-case-scenario for evaluation of forced early-ocean entry of juvenile spring chinook salmon. Periodic exposure to salinity during high tides (salinity at the net-pen site occasionally reaches 12 ppt) may afford the fish better opportunity for acclimation to saltwater challenge. A successful demonstration of forced early-ocean entry with these cultured fish may suggest similar experiments with spring chinook salmon and other fish stocks within the Columbia River Basin. For example, fish that are placed on transportation barges in the Snake River and middle Columbia River are released downstream from Bonneville Dam in the Columbia River (RKm 225). Following release from the barges, these fish must migrate downstream past known areas of intense avian predation in the upper freshwater reaches of the estuary near Rice Island and Miller Sands (RKm 40). If extended transportation and forced early-ocean entrance were shown to benefit those fish, there could be important implications with respect to recovery efforts for ESA-listed salmonid stocks from the upper Columbia and Snake Rivers.

d. Project history

The feasibility study conducted in 1997 was funded by NMFS. A draft manuscript detailing the results of the efforts is available upon request (Ledgerwood et. al., In prep.) .

e. Methods.

Detailed methodology for the sonic fish-tracking research that was conducted at the CEDC facilities in April 1997 is provided in Ledgerwood et al. (In prep.). Many of the details proposed here are similar to those associated with this earlier work.

Background

During earlier research (1977-1983) to evaluate migrational behavior and survival of marked groups of juvenile salmonids to and through the estuary (Dawley et al. 1986), the average migration rates for yearling chinook salmon were: 1) from release site to Jones Beach (RKm 75), 19 km/d (n = 55 marked groups); 2) from Jones Beach to the lower estuary near Astoria, 25 km/d (n = 51 marked groups); and from Jones Beach into the ocean plume, though poorly defined, 10 km/d (n = 29 marked groups). To our knowledge, this database remains the only evaluation of estuary to offshore migrational behavior for a multitude of Columbia River fish stocks. However, this database was limited to marked fish groups originating upstream from Jones Beach; seaward migration of fish groups originating within the estuary were not evaluated.

Study Area

The study fish for the proposed research were reared in net-pens in Youngs Bay, an intertidal area within the lower Columbia River estuary consisting largely of mud flats. Four rivers empty into the Youngs Bay area: the Klatskanie River, the Youngs River, the Lewis and Clark River, and the Skipanon River. The approximate main river channel distance from the net-pens to the confluence with the Columbia River is 9 km, and from the confluence with the Columbia River to the ocean another 20 km.

Salinity in the net-pen rearing area ranges from 0 ppt during high flow conditions to over 12 ppt during low flow conditions when study fish were present (Fox et al. 1984). Following release of net-pen fish or other fish from nearby rearing ponds and hatcheries within the bay area, it is common to see abundant populations of cormorants (*Phalacrocorax* spp.) and other species of predatory birds (terns) working in the area of the released fish--presumably preying on released fish (Jim Hill, CEDC, Astoria, OR 97103, Pers. commun., Oct 1997). Thus, fish reared at the CEDC facility provide a best-case-scenario for a study to determine benefits of forced early ocean entry: they have previous acclimation to salt water and contribution is hindered by a population of predators.

Sonic Tags and Receiving Equipment

The sonic tags (Lotek Marine Corp., CRFT 8-1, 300-kHz frequency) having a pulse coding scheme to help identify individual tags will be used. Unlike radio-transmitters whose signals are quickly attenuated in saltwater, these sonic tags have a range of about 100 m in saltwater. The Lotek tags measure 18-mm long by 8-mm in diameter, and weigh 1.5 g in air (0.35 g in water). Expected transmitter life of the tags is about 30 days (range 25 to 35 days depending on the frequency of the pulse code). Receiving equipment consists of electronic receivers (Lotek Marine Corp., Model SRX400A) and passive induction-style directional hydrophones with 20- or 30-degree beam widths.

Study Fish and Tagging

Study fish are juvenile spring chinook salmon, Willamette River Stock (Oakridge Hatchery), which are transferred to the CEDC net-pens in Youngs Bay for rearing in November. Fish from Oakridge Hatchery would normally be released into the Willamette River as yearling-plus fish in March, but fish reared at the CEDC facilities have provided higher adult contribution rates when released in April. Returning adults to Youngs Bay support a terminal fishery industry (both commercial and sport fishing).

We will select fish >125 mm fork-length for sonic tagging. Tags will be surgically implanted into the body cavity of selected fish (Hart and Summerfelt 1975, Mellas and Haynes 1985, Moore et al. 1990). Fish will be allowed at least 24 hours to recover from the effects of anesthesia and surgery in an individual net-pen prior to release. We expect to release all tagged fish within 7 days of tagging.

Fish Tracking

Generally, only a single fish will be released at a time and tracking will be accomplished using two boats fitted with directional hydrophones and receivers. Using relative signal strength and direction, boats will be maneuvered to maintain contact with the tagged fish following release. In confined areas within Youngs Bay, tracking can be accomplished using a single boat, but in the mainstem Columbia River two vessels are necessary--one vessel remaining in contact with the fish while the other vessel leap-frogs ahead. When signal strength from a tagged fish is strong, the receiver can be switched into a "pulse-counting mode" and the number of beats per second, frequency, and signal strength of the tag observed on the screen and recorded. Background noise can be filtered out in pulse-counting mode by adjusting the gain setting on the receiver. Maximum search range is obtained by switching off the "pulse counting mode" and tuning-up the gain setting of the hydrophone. Reception range depends on an operator’s ability to hear the transmitter signal as distinct from other background acoustic or electromagnetic noise.

Mapping and Physical Data

Positions of the tracking vessels (generally within 100 m of a tagged fish) will be periodically recorded using global positioning satellite (GPS) receivers. Data will include latitude, longitude, date, time, and waypoint number code. The GPS data will be downloaded (or manually keypunched) into a database system and approximate plots of tracked fish (boat positions) obtained using a moving map software program (Vista for Windows, RMS Technology, Inc., Molalla, OR).

Surface to near-bottom water-column profiles for water temperature, dissolved oxygen, and salinity will be obtained periodically during tracking using a multiparameter Hydrolab Surveyor with submersible probe and datalogger. These data will also be downloaded and stored in the database. Tides and relative current velocities are recorded using Tides and Currents software (Nautical Software, Inc., Beaverton, OR). Electronic copies of the NOAA navigational charts of the study area were obtained using Chartview software (Nautical Software, Inc., Beaverton, OR) and used as base maps on which fish tracks will be plotted.

f. Facilities and equipment.

The study would be conducted using CEDC fish held at the net-pen facilities in Youngs Bay (Columbia River). NMFS would provide project personnel, tracking equipment, and vessels. The NMFS Pt. Adams Biological Station would be the base for operations and coordination; we would utilize small vessels (16- to 25-foot vessels) for tracking within the bay and estuary, and larger (41-55-foot vessels) for use in the nearshore ocean. NMFS personnel would implant the sonic tags into study fish and conduct tracking operations and record the environmental parameters.

g. References.

Boehlert, G.W. (editor). 1997. Application of acoustic and archival tags to assess estuarine, nearshore, and offshore habitat utilization and movement by salmonids. NOAA-TM-NMFS-SWFSC-236. 62 p.

Dawley, E. M., R. D. Ledgerwood, T. H. Blahm, C. W. Sims, J. T. Durkin, R. A. Kirn, A. E. Rankis, G. E. Monan, and F. J. Ossiander. 1986. Migrational characteristics, biological observations, and relative survival of juvenile salmonids entering the Columbia River estuary, 1966-1983. Final report to Bonneville Power Administration, Contract DE-A179-84BP39652, 256 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Fox, D. S., W. Nehlsen, S. Bell, and J. Damron. 1984. The Columbia River estuary, atlas of physical and biological characteristics. Columbia River Estuary Data Development Program, Astoria, Oregon. 84 p.

Hart, L. G., and R. C. Summerfelt. 1975. Surgical procedures for implanting ultrasonic transmitters into flathead catfish (*Pylodictus olivaris*). Trans. Am. Fish. Soc. 104:56-59.

Hirose, P., M. Miller, and J. Hill. In prep. Columbia River: Terminal fisheries research report. Ann. Report to Bonneville Power Administration, Project 93-06000. Oregon Department of Fish and Wildlife and Clatsop Economic Development Commission.

Ledgerwood, R. D., E. M. Dawley, L. G. Gilbreath, L. T. Parker, B. P. Sandford, and S. J. Grabowski. 1994. Relative survival of subyearling chinook salmon after passage through the bypass system at the First Powerhouse or a turbine at the First or Second Powerhouse and through the tailrace basins at Bonneville Dam, 1992. Report to the U.S. Army Corps of Engineers, Contract DACW57-85-H-0001, 53 p. + Appendices. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Ledgerwood, R. D., B. Ryan, and R. Iwamoto. In prep. Estuarine and nearshore-ocean sonic tracking of juvenile spring chinook salmon from the Columbia River. Unpublished manuscript. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Mellas, E. J., and J. M. Haynes. 1985. Swimming performance and behavior of rainbow trout (*Salmo gairdneri*) and white perch (*Morone americana*): effects of attaching telemetry transmitters. Can. J. Fish. Aquat. Sci. 42:488-493.

Miller, D. R. 1992. Distribution, abundance, and food of juvenile chinook salmon in the nearshore ocean adjacent to the Columbia River. Workshop on the growth, distribution, and mortality of juvenile pacific salmon in coastal waters. p. 1-33. Sidney, British Columbia, Oct. 17-18 1992. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Miller, D. R., J. G. Williams, and C. W. Sims. 1983. Distribution, abundance, and growth of juvenile salmonids off the coast of Oregon and Washington, summer 1980. Fish. Res. 2:1-17.

Moore, A., I. C. Russell, and E. C. E. Potter. 1990. The effects of intraperitoneal implanted dummy acoustic transmitters on the behavior and physiology of juvenile Atlantic salmon, *Salmo salar* L. J. Fish Biol. 37:713-721.

Reimers, P. E. 1973. The length of residence of juvenile fall chinook salmon in Sixes River, Oregon. Res. Rep. Fish Comm. Oreg. 4(2):3-43.

Schreck, C. B., L. E. Davis, and C. Seals. In Prep. Evaluation of procedures for collection, bypass, and transport of outmigrating salmonids. Objective 1: Migratory behavior and survival of yearling spring chinook salmon in the lower Columbia River estuary. Report to the U.S. Army Corps of Engineers, Contract MPE-96-10. Oregon Cooperative Fishery Research Unit, Dept. Fisheries and Wildlife, Corvallis, Oregon.

Wagner, H. H., F. P. Conte, and J. L. Fessler. 1969. Development of osmotic and ionic regulation in two races of chinook salmon (*Oncorhynchus tshawytscha*) Comp. Biochem. Physiol. 29:325-341.

Section 8. Relationships to other projects

The CEDC terminal-fishery project would be the initial beneficiary of this research, although benefits could eventually expand to include other fish groups (including ESA-listed species) where transportation to force early ocean entrance and avoid predation is possible. We hope to demonstrate that fish can be released earlier than normal and forced into the ocean using strong tidal currents. If migratory behavior suggests that this strategy can be successful, then a larger-scale study using groups represented by CWT could be used as the validation of the concept.

Section 9. Key personnel

1) Richard Ledgerwood, Fisheries Research Biologist, Principal Investigator; 0.4 FTE.

Responsible for all aspects of the research project, the principal investigator coordinates activities and consults frequently with the project leader, who is responsible for the daily field activities. These coordinated activities include, but are not limited to, purchasing of equipment, hiring of seasonal personnel, setting work and other schedules, performance of the daily research routine, and analyses and report writing. The principal investigator, while not routinely scheduled for fish tracking activities, will be readily available as an emergency fill-in or during periods of extended tracking hours.

Relevant research includes: 1) Assisted in a program aimed at defining the migrational and behavioral characteristics of juvenile salmonids in the Columbia River and estuary (1977-1983). Included was a study focusing on stomach content analyses of specific tagged groups of juvenile salmon captured in fresh water, in brackish water, and in offshore marine areas; 2) research to improve the collection of juvenile salmon and steelhead at various dams on the Columbia and Snake Rivers and to document survival of juvenile salmonids through Bonneville Dam (1984-1993); 3) research to evaluate migrational timing and survival of passive integrated transponder (PIT) tagged juvenile salmonids from the Snake River Transportation Study to the Columbia River estuary (1995-1998); 4) and feasibility research to monitor seaward migration of individual juvenile salmonids implanted with sonic tags and released from the Youngs Bay Terminal Fishery Project in the Columbia River estuary (1997).

Received his BA degree in biology from Linfield College, McMinnville, OR in 1970 and his MS degree from the University of Washington, Seattle, WA in 1973. Worked as a fisheries research biologist in El Salvador for 2 years (1975-76, Peace Corps) and has been employed since 1977 by the National Marine Fisheries Service.

Relevant citations:

Ledgerwood, R. D., B. Ryan, and R. N. Iwamoto. In prep. Estuarine and nearshore-ocean sonic tracking of juvenile spring chinook salmon from the Columbia River, 1997. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Ledgerwood, R. D., E. M. Dawley, P. J. Bentley, L. G. Gilbreath, T. P. Poe, and H. L. Hansen. 1993. Effectiveness of predator removal for protecting juvenile fall chinook salmon released from Bonneville Hatchery, 1991. U.S. Dep. Commer., NOAA Tech. Memo., NMFS-NWFSC-9, 63 p.

Ledgerwood, R. D., F. P. Thrower, and E. M. Dawley. 1991. Diel sampling of migratory juvenile salmonids in the Columbia River estuary. Fish. Bull., U. S. 89:69-78.

Dawley, E. M., R. D. Ledgerwood, T. H. Blahm, C. W. Sims, J. T. Durkin, R. A. Kirn, A. E. Rankis, G. E. Monan, and F. J. Ossiander. 1986. Migrational characteristics, biological observations, and relative survival of juvenile salmonids entering the Columbia River Estuary, 1966-1983. Final Report to BPA, Contract DE-A179-84BP39652. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish Serv., Northwest and Alaska Fish Cent., Seattle, WA, 256 p.

Ledgerwood, R. D., and E. M. Dawley. 1982. Stomach fullness of individual stocks of salmonid smolts entering the Columbia River estuary during 1979, 80, and 81. Proceedings of the 33rd. Annual Northwest Fish Culture Workshop (Informal Records of Presentation), p. 265-278.

2) Brad Ryan, Fisheries Research Biologist, Project Leader; 0.4 FTE.

Reports to the principal investigator and is responsible for planning, purchasing, hiring of seasonal personnel, conduct of the daily research activities, and reporting of research findings.

Relevant research accomplishments include: 1) co-investigator of sonic tracking research to monitor seaward migration of individual juvenile salmonids released from the Youngs Bay Terminal Fishery Project in the Columbia River estuary (1997); 2) supervised sampling and observation of salmonids and non-salmonids in the Columbia River Basin for signs of Gas Bubble Disease (GBD). Produced an annual and final report summarizing GBD data collected from 1994 to 1997; 3) sampled and PIT tagged juvenile salmonids from Idaho rivers and streams (1997).

Received BS degree, December 1993, University of Portland; Portland, OR;
major: Biology; minor: Chemistry.

Relevant citations:

Toner, M. A., E. M. Dawley, and B. Ryan. 1995. Evaluation of the effects of dissolved gas supersaturation on fish and invertebrates downstream from Bonneville, Ice Harbor, and Priest Rapids Dams, 1994. Report to the U.S. Army Corps of Engineers, Contract E96940029, 43 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097).

Schrank, B. P., B. A. Ryan, and E. M. Dawley. 1996. Evaluation of the effects of dissolved gas supersaturation on fish and invertebrates in Priest Rapids Reservoir, and downstream from Bonneville and Ice Harbor Dams, 1995. Report to the U.S. Army Corps of Engineers, Contract E96940029. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Schrank, B. P., B. A. Ryan, and E. M. Dawley. 1997. Effects of Dissolved Gas Supersaturation on Fish Residing in The Snake and Columbia Rivers, 1996. In prep.

Report to the U.S. Army Corps of Engineers, Contract 96-BI-93605. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Ryan, B. A., and E. M. Dawley. 1998. Effects of Dissolved Gas Supersaturation on Fish Residing in the Snake and Columbia Rivers, 1997. In prep. Report to the U.S. Army Corps of Engineers, Contract 96-BI-93605. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Ledgerwood, R. D., B. Ryan, and R. N. Iwamoto. In prep. Estuarine and nearshore-ocean sonic tracking of juvenile spring chinook salmon from the Columbia River. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Section 10. Information/technology transfer

We will provide an annual report, publish results in a peer-reviewed journal (if warranted), and participate in BPA and other research reviews and workshops.